National Aeronautics and Space Administration

TPF-I Mid-IR Interferometry Technology

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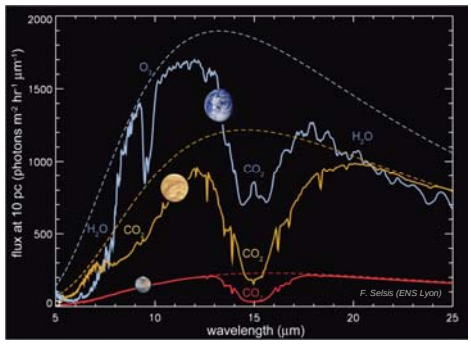
Project Objective

The technology being demonstrated through TPF-I will enable mid-infrared observations of Earth-like exoplanets at wavelengths between 6 and 20 microns. This band is rich in key atmospheric bio-signatures, including H_2O, CH_4, O_3, and CO_2. The continuum windows in this band will be used to determine surface temperature.



Project Description

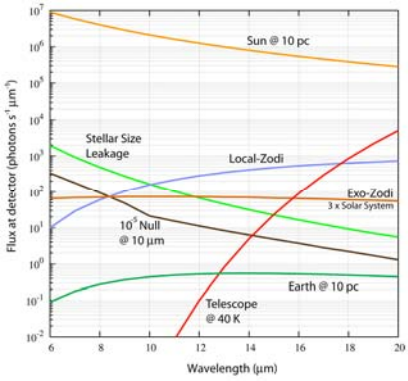
This work embraces a vigorous technology program, including component development, integrated testbeds, and end-to-end modeling being carried out in the areas of formation flying and mid-infrared starlight suppression.

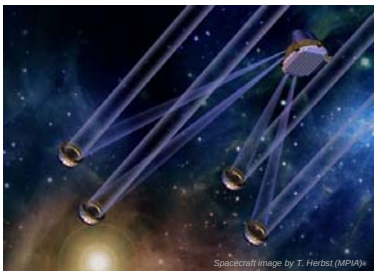
http://planetquest.jpl.nasa.gov/TPF-I/

Project Results

Interferometer technology is key to high-dynamic range measurements of planet spectra at mid-infrared wavelengths. The observatory needs to be 10-20 times larger than a near-infrared observatory with the same angular resolution. Designing the observatory as an interferometer offers the possibility of greatly reducing the overall mass and thus the cost of the mission.

Starlight suppression to 10^{-5} reduces the stellar photon noise to below the local and exo-zodiacal background.





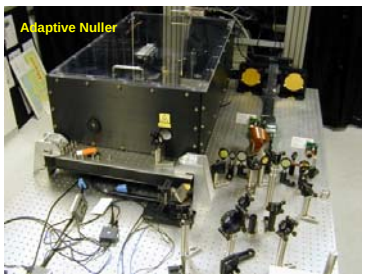
Shared NASA and ESA Mission Concept: 'Emma' geometry reduces complexity and increases sky coverage

Accomplished Milestones

TPF-I Milestone #1: Phase compensation better than 5 nm RMS, with intensity compensation better than 0.2% was demonstrated with the Adaptive Nuller. (24 July 2007)

TPF-I Milestone #2: Guidance navigation and control algorithms for a formation of two telescopes were demonstrated with traceability to flight in a ground-based robotic testbed. (16 January 2008)

Mid-IR laser nulling results have exceeded flight requirements. Our current broadband performance would add only 5% to the integration time required to detect an Earth at 15 pc (1.2×10^{-5} null @ 32% BW)



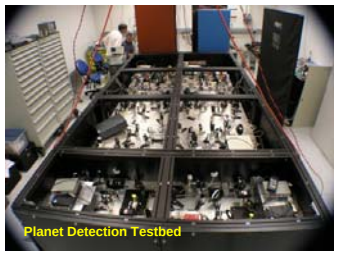
"TFP-I Milestone #1 Report: Amplitude and Phase Control Demonstration," Edited by R.D. Peters, P.R. Lawson, and O.P. Lay JPL Document 3839, 24 July 24 2007

"TFP-I Technology Milestone #2 Report: Formation Control Performance Demonstration," Edited by D.P. Scharf and P.R. Lawson JPL Document 43009, 16 January 2008

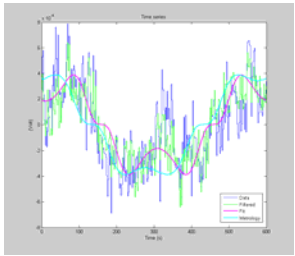
Future Milestones

TPF-I Milestone #3: Mid-infrared nulling of 10^{-5} over a 25% bandwidth; three 6-hour experiments. (Whitepaper signed, 10 October 2007)

TPF-I Milestone #4: Laboratory demonstration of Planet signal extraction with a flight-like nulling system testbed. (Whitepaper in preparation)



Planet signal extraction with the Planet Detection Testbed: Planet signal 940,000 fainter than the star with null depth of 70,000 to 100,000. (Preparations for Milestone #4)



Benefits to NASA and JPL

TPF-I technology development is directly responsive to recommendations by the AAAC ExoPlanet Task Force and has established JPL as the world's leader in mid-IR exoplanet technology, strategically positioning the lab as the key center for mid-IR interferometry missions.

Publications

Ksendzov, A., et al. "Characterization of mid-infrared single-mode fibers as modal fibers," Appl. Opt. 46, 7957 (2007); Ksendzov, A. et al. "Modal filtering in mid-infrared using silver halide fibers," Appl. Opt. (submitted); Peters, R.D., et al. "Broadband phase and intensity compensation with a deformable mirror for an interferometric nuller," Appl. Opt. (in preparation); Gappinger, R.O., "Mid-infrared interferometric nulling with implications for exoplanet detection," Appl. Opt. (in prepration)

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